Chapter 14

Energy transition in Switzerland

Anna KUCHARSKA[398]

Energy balance structure

As a result of a combination of several factors, Switzerland is unique among European countries. First, it is located in the middle of Europe, so it has naturally become a trans-border corridor of energy transmission. Second, it is not a member of the EU or EEA, which gives it a unique legal status in the face of advancing physical integration with neighboring countries belonging to the EU. Besides, Switzerland is 100% dependent on the import of oil, natural gas, and uranium. Because of the high level of civil development, the country has a great demand for energy despite its small surface area and population. And finally, the decentralized character of the political system and the tradition of citizens' direct participation in political life through referenda make changes in the country occur slowly and gradually, and they cannot affect citizens too much, since otherwise they simply do not agree to the reforms.

In Switzerland their full dependence on fossil fuels is connected with the high demand for energy. In 2014, the total final energy consumption in Switzerland was 825,770 TJ, in which 21.4% was energy from RES. In 2014, the share of RES in final energy consumption was 176,902 TJ, which means a decrease by 6.4% in comparison to 2013 (189,001 TJ). The share of so-called new RES (i.e., without water energy) was 9,415 TJ in 2014 (in 2013: 7,913 TJ; i.e., growth by 19%), which in 2014 made it possible to produce 3.9% of electricity. Total

[398] Anna Kucharska, MSc, PhD Candidate, Faculty of International and Political Studies, Jagiellonian University, e-mail: anna.maria.kucharska@doctoral.uj.edu.pl

production of electricity from RES was 142,446 TJ (2012: 142,697 TJ, i.e., a decrease by 0.2%). In 2014, 47,768 TJ of heat from RES was consumed (2013: 52,447 TJ; a reduction of 8.9%).[399]

The share of non-renewable energy carriers in total consumption is 78.58%. Oil is mostly imported from Africa. In Switzerland, there are huge refineries, so it is a significant importer of oil derivatives for Europe (e.g., gasoline). Most natural gas imported to Switzerland comes from EU countries and Norway, and 1/4 from Russia. Switzerland has no direct agreements with Russia. For the import of natural gas, Switzerland is totally dependent on the transmission network of EU countries. Switzerland's problem is the lack of its own gas storage facilities. For geological and technical reasons, Switzerland was unable to develop great gas storage facilities, so it only has transmission networks and small containers to balance daily gas demand.

Currently, 5 nuclear power plants in Switzerland ensure 40-45% of its electricity. A higher share in energy production occurs in winter due to the lower use of RES. Uranium is supplied from politically stable regions such as e.g., the USA, Canada, or Australia, so dependence on this resource is not considered in terms of any threat to the country's security. It is also emphasized that Switzerland has learnt to store radioactive waste in a safe way, and the amount of needed nuclear fuel is many times lower than other fossil fuels. Besides, it is a zero emission source of energy with a stable volume of production, which is important for the mostly obsolete Swiss transmission networks.[400] Despite substantial social support for nuclear energy, after the Fukushima disaster Switzerland began work on Energy Strategy until 2050 (*Energiestrategie 2050*) assuming a gradual resignation from nuclear energy, which was to begin by not building new blocks or extending the use of existing ones unless necessary for safety reasons.[401]

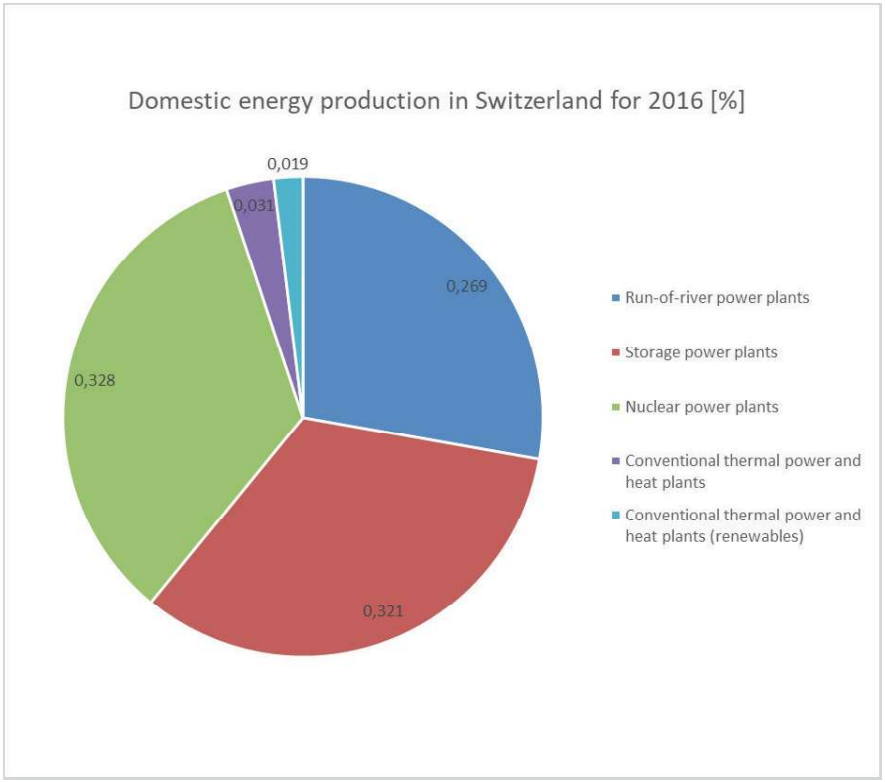
---

[399] *Schweizerische Statistik der Erneuerbaren Energien. Ausgabe 2014*, UVEK, BFE, Bern, September 2015, pp. 40-41.

[400] J. Lundsgaard-Hansen, *Energiestrategie 2050 – das Eis ist dünn. Die Schweiz und Deutschland auf neuen Wegen*, published by NZZ, Zürich 2013, p. 82.

[401] *Energiespeicher in der Schweiz. Bedarf, Wirtschaftlichkeit und Rahmenbedingungen im Kontext der Energiestrategie 2050*, Schlussbericht 12. December 2013, UVEK, BFE, Bern 2013, p. 30.

Chart 30. Domestic energy production in Switzerland for 2016 [%]



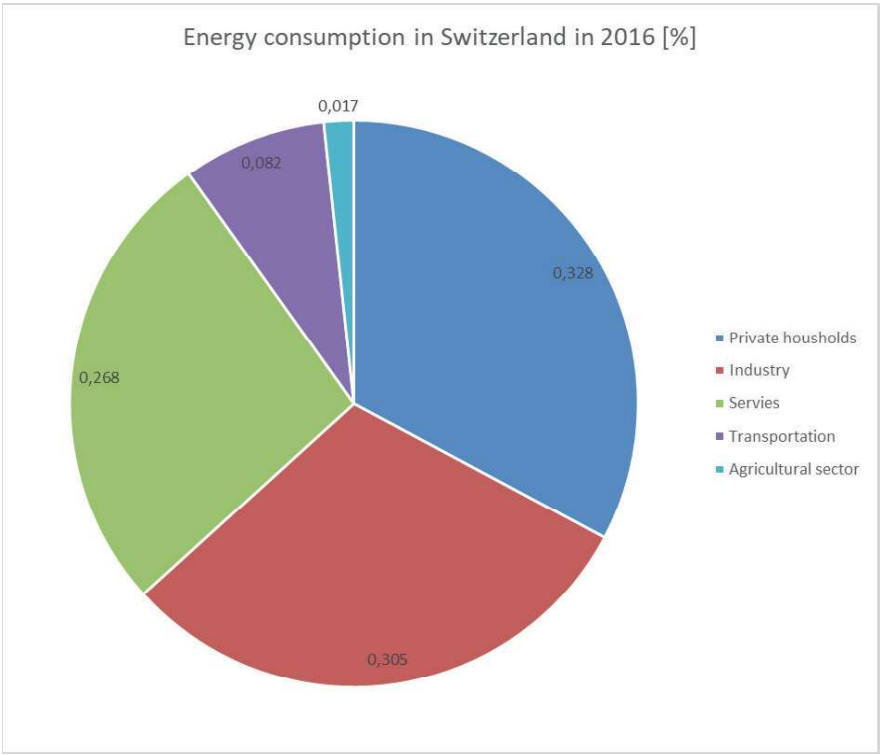
Source: *Schweizerische Elektrizitätsstatistik 2016*, BFE, Bern, p. 3.

Swiss model of energy strategy

Energy Strategy Until 2050 is an extension of the document of 2007, which applies to the period until 2035: Energy perspectives (*Energieperspektiven 2035*). The document that refers to Switzerland's energy strategy until 2050 updates socio-economic data, technical requirements and energy policy, and presents goals assuming gradual transformation of the Swiss energy system until 2050. The Strategy includes 3 scenarios for the development of energy supply and demand in Switzerland and 7 priorities for Swiss energy policy. The key ones raise the share of RES in electricity production, strengthen research on the energy industry, and extend and transform energy

networks and storage facilities.[402] The increase in electricity production from RES assumed until 2050 involves, according to different sources, an annual increase in the share of water energy by 3.2 TWh up to 38.6 TWh; wind energy should reach the production capacity of 4.3 TWh; photovoltaics, 11.2 TWh. It is also necessary to guarantee enough available capacity through appropriate storage capacities and sufficient network capacity, already emphasized by the Ministry of Energy in the Strategy Until 2035.[403]

Chart 31. Energy consumption in Switzerland in 2016 [%]



Source: *Schweizerische Elektrizitätsstatistik 2016*, BFE, Bern, p. 4.

The Swiss Energy Strategy presents 3 possible scenarios of development for Swiss energy policy before 2050. Thus, Switzerland not

[402] *Die Energieperspektiven für die Schweiz..., op. cit.*, p. 1.

[403] *Energiespeicher in der Schweiz.., op. cit.*, p. 34.

only has aplan, but it is flexibly developing its energy policy to allow the adoption of whatever variation is the most beneficial socially and economically. The introduction of scenarios depends i.a., on technological advancement allowing the application of specific system activities.[404] The general priorities of energy policy set in the Strategy refer to all three scenarios, but differ in the ways and degree of their achievement. All scenarios assume a decrease in importation of fossil energy carriers, reduction of CO2 emissions, an increase in the use of RES, and rising energy efficiency.[405]

All the scenarios assume a decrease in the import of fossil energy carriers from the current 80% of total energy consumption to 29-62% depending on the scenario.[406] The increase in the share of RES in electricity production assumed for 2050 is by 11 TWh for photovoltaics, 4 TWh for wind power plants, 4 TWh for geothermal energy, and 16 TWh for run-of-river hydroelectricity. The Swiss energy networks adopting the anticipated volumes of electricity from wind, solar, and geothermal power plants will be possible for all three scenarios thanks to the high flexibility of pumped storage power plants and power plants at water reservoirs.[407] They are of key importance in securing Swiss electricity supply. With their huge energy potential, they are currently able to cover in critical situations the majority of Swiss electricity demand.

The least demanding scenario in terms of achievement of general energy priorities is the *Weiter wie bisher* – WWB scenario *(The same as before)*, whose name clearly shows the policy direction. WWB is oriented to the existing situation and the possibilities of developing energy policy on the basis of currently available instruments and tools.[408] This variant is most often referred to when planning current activities and the near future.

---

[404] *Ist das geplante Stromsystem der Schweiz für die Umsetzung der Energiestrategie 2050 aus technischer Sicht geeignet? Swiss Energy Strategy 2050 and the Consequences for Electricity Grid Operation – Full Report* , SATW, Zürich, Mai/Juli 2014, http://www.satw.ch/publikationen/SATW_Energiestudie_def.pdf (accessed: 6.11.2016), p. 82.

[405] *Die Energieperspektiven für die Schweiz..., op. cit.*, p. 617.

[406] *Ibidem.*

[407] *Ist das geplante Stromsystem..., op. cit.*, p. 11.

[408] *Die Energieperspektiven für die Schweiz..., op. cit.*, p. 3.

a) Development of renewable energy sources

The scenario titled *Neue Energiepolitik* – NEP (New energy policy) is the scenario of the federal government of May 2011. It presents a probable path for changing electricity consumption and production in Switzerland until 2050, providing the basis for the assumption of reducing CO2 by 1.0-1.5 tons per capita. This would mean that the goal of reducing CO2 emissions before 2020 by 20% in comparison to 2000 is met. An important aspect of this scenario assumes that constantly available biomass resources are limited, both within the country and globally. Therefore, the NEP scenario excludes the possibility of basing itself on the unlimited import of biogenous energy carriers. It points to the need for international cooperation, especially in terms of research and development, in order to have a uniform policy of CO_2 reduction and energy efficiency improvement. In particular, it emphasizes the need to develop and implement new technologies on the basis of division of tasks on the international scale.[409]

The Swiss Ministry of Energy anticipates extending the power of pumped storage power plants from 1.8 GW to approx. 6 GW before 2025. At the same time, the storage capacity of the water tanks is to be increased up to 200 GWh.[410] In 2015, 37 hydropower plants operated. 15 of them were newly built, 12 were restructured, and 10, adjusted. The Russein power plant has the highest energy production: 66.8 GWh. At the end of 2015, more hydropower plants that were being built will ensure the level of electricity production of 321 GWh. As much as 18% of that will be provided by the extension of the Krafthaus Prutz/Ried hydropower plant.[411] Despite their high potential and importance for the Swiss energy industry, hydropower plants have losses. The classic economic model in which water is released at the maximum load has lost its profitability since the differences in wholesale electricity prices (so-called spreads) began decreasing during the day. This is the result of factors such as low prices of fossil fuels and rights to CO_2 emissions in previous years. An important factor was also the extension of installations using

[409] *Ibidem*, p. 4.

[410] *Ist das geplante Stromsystem..., op. cit.*, p. 7.

[411] *Schweizerische Elektrizitätsstatistik 2015*, BFE, Bern, p. 39.

solar radiation, which have priority for entering higher amounts of energy into the network in the afternoon.[412]

Achieving 11.2 TWh electricity from photovoltaics a year, which is the Ministry's target, means the necessity to extend solar installations by 9 GW a year. With the technology available now, 17% of the surface area (about 80 km_2) allocated for development (industry, residential areas) will be used for this purpose, which conforms to Swiss spatial requirements. The problem is, however, that the assumptions of the Swiss Ministry of Energy are based on optimum solar exposure, i.e., 1,250 full hours of load a year. However, data reported by companies applying for subsidies from the instrument of support for RES shows that actual solar exposure is approx. 900 full hours a year. Taking this data into consideration, the value of necessary capacity of 12 GW should be used instead of 9 GW, so that the target of annual electricity production could be 11.2 TWh. In this case, the above-mentioned data concerning spatial demand must be raised by 1/3.[413] Forecasts of growth in the use of photovoltaics in Switzerland connected with the development of the expected potential of this source of energy are estimated at between 0.1 and 2.7 TWh by 2035, and by 2050, the values will be 0.2-9.7 TWh.[414] This increase means the multiplication of current electricity production, i.e., 0.02 TWh, 6- or even 100-fold by 2035. Before 2050, growth by 10 to even 500 times is expected in comparison to contemporary production. In terms of production costs, photovoltaics is currently the most expensive technology of electricity production in Switzerland; the price of produced energy is 40-100 Rp./kWh.[415]

A wind power plant already functions as a mature and economically competitive technology with high developmental potential. The costs of production are lower than in the case of a small hydro power plant, but largely depend on location. This kind of energy source, however, is not usually approved by the local community. In Switzerland, the development of wind energy is very limited by territorial conditions,

[412] *Energiespeicher in der Schweiz.., op. cit.*, p. 34.

[413] *Ist das geplante Stromsystem..., op. cit.*, p. 51.

[414] Span depending on the adopted scenario from the Energy Strategy Until 2050.

[415] *Energie-Strategie 2050. Impulse für die schweizerische Energiepolitik. Grundlagenbericht*, Energie Trialog Schweiz, Zürich 2010, pp. 50-59.

because there are few available locations appropriate for the development of such installations. Currently, in Switzerland there are 13 wind installations, which produce 0.02 TWh annually. Approximately 90 more installations are planned. To achieve the target of producing 2 TWh, set in the Energy Strategy, it would be necessary to install approximately 1,200 wind turbines. According to many studies carried out by research centers at the request of the Ministry of Energy, the increase in the use of such an energy source could reach 0.6 to 2.2 TWh a year by 2035. This way, today's production would be increased by 40 or even 100 times. It is estimated that the level of wind energy use will grow considerably by 2035, but before 2050, this progress will no longer take place. However, the development of wind energy is strongly dependent on the demand and location possibilities.[416]

b) Increase in energy efficiency and international competitiveness

The "Political Measures" scenario (*Politische Massnahmen* – POM) assumes a politically coordinated set of instruments used to achieve the goals of energy transition. The priority in this scenario lies in raising energy efficiency and results from the intention to secure in the future sufficient electricity supplies because of giving up on nuclear energy. For these reasons, different variants of covering electricity demand are taken into consideration. For example, a number of in-depth analyses were prepared, concerning the effects of the growing share of fluctuating energy production from RES in the energy mix, cogeneration, electromobility, and biomass potential.[417]

The emphasis on raising energy efficiency is considered to be much more beneficial than extending energy production. What is important in this aspect is such energy sources as photovoltaics, wind energy, and biomass, which are not a valuable and freely available resource because of the established density of energy and power per surface area unit.[418] In other words, due to spatial limitations, in Switzerland there are not many opportunities to extend wind or solar farms. Therefore, the goal is to maximize energy efficiency in energy production using the available locations.

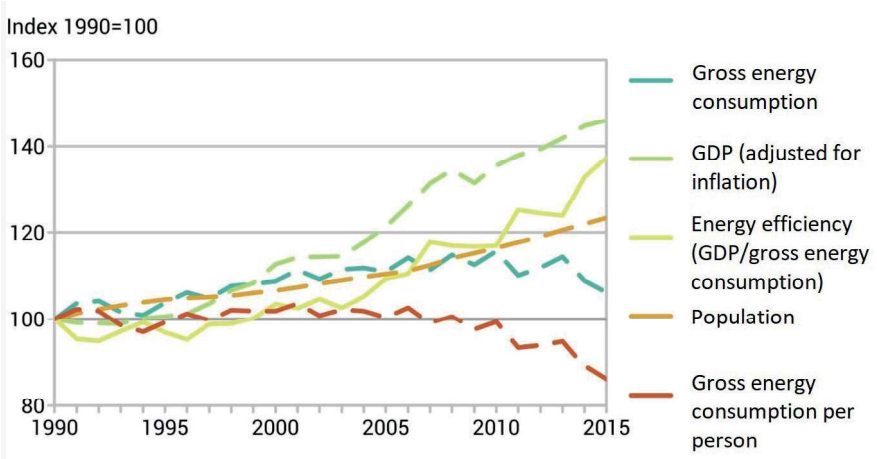
---

[416] *Ibidem*.

[417] *Die Energieperspektiven für die Schweiz..., op. cit.*, p. 1.

[418] *Ibidem*, pp. 4-5.

Chart 32. Energy efficiency in Switzerland (1990-2015)



Source: Bundesamt für Statistik, *Umweltindikator – Energieeffizienz*, Bern 2016 [Internet:] https://www.bfs.admin.ch/bfs/de/home/statistiken/raum-umwelt/ressourcen/umweltindikatorensystem/nutzung-natuerliche-ressourcen/energieeffizienz.html (accessed: 27.08.2017).

The aspect of raising energy efficiency is connected with the issue of capturing and storing energy surpluses. Further, energy storage facilities are connected with the area of industrial networks, because they have to be integrated with them. It is necessary to raise efficiency, not only in the sphere of production, but also the whole energy infrastructure. The classic tasks of energy storage facilities involve compensating annual changes in consumption and fluctuations of daily peaks, so the significance of RES grows along with their development. The strong need to store energy occurs when energy production from RES dependent on external conditions is periodically insufficient to meet the demand. On the one hand, the development of research concerning new technologies plays a big role in the development of storage facilities. On the other hand, changes in the system of remunerations for controlled RES, i.e., hydro power plants, are also important.[419]

The goal of the implementing political instruments proposed by the POM scenario is to activate the potential of energy efficiency. As a result of the activities, the final consumption of energy may drop by 33% before 2050 in relation to present consumption. It is anticipated

[419] *Energiespeicher in der Schweiz.., op. cit.*, pp. 35-37.

that this may stabilize the consumption of electricity, and growth will begin again after 2035 because of stronger electrification of traffic by approx. 3.4%.[420]

Unlike in the NEP scenario, the assumptions of POM include pursuing the nation's autonomy and independence in satisfying the demand for energy at the cost of lowering the degree of achievement of energy policy priorities. Activities proposed in POM may be implemented in Switzerland independently of international energy policy, except the boundary values of emissions in traffic. Dependence on measures implemented internationally occurs in industries which are not very well developed in Switzerland, e.g., the automotive industry, because Switzerland does not produce vehicles. Hence, the growth of vehicle efficiency in this country is closely connected with the activities of countries that are producers of cars.[421]

The increase of energy efficiency in all kinds of fuel, including alternative (biogenous) fuels, is still significant. In the end, electromobility is expected to be competitive to conventional combustion engines in terms of efficiency. A technological leap in solutions for batteries may make the market share of electric vehicles grow, but increasing the performance of combustion engines may temporarily inhibit the expansion of electric cars. Hybrid vehicles make use of the development of technology in both areas and may be regarded as an element of the transition phase to electric mobility together with so-called range extenders. Electromobility must develop as part of a collaboration of world actors and responsible regional development, and be properly carried out in this sense.[422] In the case of Switzerland, the automotive parts industry, with a turnover of approx. CHF 14 billion, is an important branch of industry. Thanks to investments in R&D and the production of highly specialized parts it has good recognition all over the world.[423] Hence, the potential existing in this area can be used in the field of electromobility along with technologies developed in Switzerland, such as power-to-gas.

---

[420] *Die Energieperspektiven für die Schweiz..., op. cit.*, p. 615.

[421] *Ibidem*, pp. 4-5.

[422] *Elektromobilität 2012. Bericht des Bundesamts für Strassen ASTRA,*UVEK, ASTRA, October 2012, p. 3.

[423] *Ibidem*, p. 5.

c) New technological solutions

The increase of fluctuating production of energy combined with the increase of national share of RES in electricity production is associated with some challenges. What is necessary is both higher shares of regulatory production (pumped storage and reservoir power stations, gas-steam systems, or cogeneration installations), but also the extension of extra seasonal storage capacities. It is still not stated clearly in Swiss documents what the combination of changeable energy production with the needed storage capacities or control through market stimuli will look like. Yet, the need for change in the present market structure is forecast. This also involves the improvement of distribution networks and the distribution system.[424] So far, the emphasis is on the development of technology for storing energy surpluses.

Hydrogen produced in the process of electrolysis from electricity generated from wind or solar energy, but also from a temporary energy surplus from conventional power plants, can be used for storage of energy surpluses produced by RES. Hydrogen obtained this way can then be reused to charge vehicles or in power plants. Hydrogen can also be used like current hydropower plants in emergency situations. The potential of this technology is attractive because it enables both short-term (e.g., a week) and seasonal energy storage.[425] For these reasons, research is being carried out in Switzerland to work out concepts appropriate for small photovoltaic power plants combined with hydrogen production and the use of fuel cells.[426] In 2015, Switzerland launched a pilot programme of a power plant generating electricity from RES, where installations using power-to-gas were installed. As planned, gas produced this way is to be used as eco fuel for vehicles. The companies involved in the project assume that the concept will be used on a large scale in the future in the area of environment-friendly mobility.[427]

Making up for the lack of possibilities of gas storage, Switzerland decided to develop modern technologies and supplement the energy reserves system with storage facilities in the form of batteries, com-

---

[424] *Die Energieperspektiven für die Schweiz...*, *op. cit.*, p. 617.

[425] *Energiespeicher in der Schweiz..*, *op. cit.*, p. 42.

[426] *Elektromobilität 2012...*, *op. cit.*, p. 3.

[427] *ETOGAS constructs the First Power-to-Gas plant in Switzerland*, Press Information, 22.01.2015, , http://etogas.com/fileadmin/documents/news/Pressemitteilung_EN/2015-01-22_EtG_PI_final_EN_first_PtG_plant_Switzerland.pdf (accessed: 6.11.2016).

pressed air containers, or electrothermal tanks. These, however, are technologies that are still being tested and only have the potential to be used short-term. The *Vehicle to Grid* (V2G) programme is one such concept. It assumes vehicles can be used as buffers for irregular, unplanned surpluses of energy from RES. At the moment, the life cycle of batteries is too low for a vehicle, and additionally shortens after each charging. Therefore, the aim of this concept is also to develop a technology that would solve problems typical of batteries, such as an insufficient life cycle for the vehicle, additionally decreasing at each charging.[428]

The problem is, however, that at present, the process of electrolysis in order to obtain hydrogen and its re-conversion to electricity is still not very effective and involves substantial loss of energy. Despite intensive research in this regard, the approach of the government to this solution and to batteries is rather conservative, because we cannot be fully sure yet that it will be possible to really apply the solutions to store electricity.[429]

Energy security

Geopolitical location and relationships with the European Union are very important for the energy security of Switzerland. The location of Switzerland in the center of Europe gives the country a strategic character in terms of international energy trade, as more than 40 cross-border connections cross there[430], ensuring it a considerable share in the international exchange of energy: 10% of all European transmission of electricity. Switzerland is practically an integral part of the European energy system, which causes mutual dependence of Switzerland and the European Union. Access to the internal European energy market is attractive to Switzerland due to its economic attractiveness and the security of supply guaranteed by the Union.[431]

[428] *Elektromobilität 2012..., op. cit.*, p. 3.

[429] *Ibidem*.

[430] W. Kwinta, *Rynek energii: Szwajcaria [Energy Market: Switzerland]* [in:] *Polska Energia*, no. 6/2011.

[431] *Europäischer Markt für die Schweiz wichtig*, Schweizerische Bundeskanzlei, Bern, https://www.news.admin.ch/message/index.html?lang=de&print_style=yes&msgid=55212 (accessed: 6.11.2016).

For the EU, Switzerland is a corridor of electricity transmission. The country is located on the north-south axis of energy transmission, especially useful for Italy, which imports its electricity this way. Import of natural gas from a gas pipeline running through the Swiss Alps is equally important for Italy, accounting for 20% of the Italian demand for gas. Switzerland has more than a dozen interconnections with gas pipelines running from Germany and France. Besides, Swiss storage capacities of hydropower stations in the Alps, which are available much quicker than those of traditional fossil fuel power stations, play an important role.[432] Thus, Switzerland is a hub of cross-border connections of European energy trade.

Switzerland is a member of the European Network of electricity transmission system operators (ENTSO-E) and shares with neighboring EU countries numerous points of entry to and exit from the transmission network. From that system of high voltage transmission networks, electricity is distributed to supra-regional, regional, and local end customers.[433] For decades, Swiss energy enterprises have been participants of the European energy market as sellers, distributors, shareholders, and network or power plant operators. With the environment-friendly production of electricity dominant in its energy mix, and because of being the center of European energy exchange due to its location, Switzerland is very important for the EU.[434]

The basic energy-related goals of the EU are the security of energy supplies in three categories: reliable and sufficient, competitive and economically profitable, and environment- and climate-friendly. This understanding of energy supply security results in certain tasks and obligations. The development of the energy market in the EU also has an influence on Swiss energy legislation, supply security, electricity flows, and thus, requirements of the transmission network. It is essential for Switzerland to become part of the future European system of high voltage transmission networks (the Super grid).[435]

---

[432] *Analyse der Schweizer Energieversorgungssicherheit. Eine Abschätzung der Verwundbarkeit des Energiesystems*, ETH-UNS Projekt-Schlussbericht, Zürich 2013, p. 12.

[433] *Ibidem*.

[434] *Stromabkommen mit der EU*, UVEK, https://www.uvek.admin.ch/uvek/de/home/energie/stromabkommen-mit-eu.html (accessed: 6.11.2016).

[435] *Zukunft Stromversorgung Schweiz*, Akademien der Wissenschaften Schweiz, Bern, July 2012, p. 34.

But Switzerland is neither a member of the EU or of the EEA. Individual agreements and contracts necessary for fluent collaboration or facilitating it, including bilateral electricity agreements, have been negotiated with the EU. The electricity agreement, which is an element of the third package of regulations concerning internal energy market, allows Switzerland free exchange of electricity with other countries and thus, equal chances on the European energy market. The goal of this agreement between Switzerland and the EU is a common, competitive, and consumer-friendly electricity market with high security of supplies for Europe.[436]

Using its negotiating position, during negotiations on the electricity agreement, Switzerland rejected the issue of extending renewable energy sources and improving energy efficiency. It was regarded as unnecessary because of considerable financial encumbrances for the society that cannot be fully forecast, especially in the area of heat engineering and transport.[437]

Both entities, Switzerland and the EU, have some interest in cooperation. The bilateral agreement should allow the Swiss energy industry and offices to further develop as part of the European connections system. But individual bilateral agreements are not enough to ensure Switzerland energy security, especially since adopting the Lisbon Treaty. In this document, the EU established its own and its member states' competence regarding energy policy and made a division between them; moreover, it was set out that third party states, such as Switzerland, would be treated as secondary in the case of emergencies or import needs.

The delayed liberalization of the Swiss energy market is also a problematic issue. Its goal is to strengthen competition on the energy market and to reduce the role of previously dominant energy producers and energy system operators, and thus, to allow consumers free choice of energy providers. As expected by the EU, liberalization will be one element of guaranteeing energy supply security and sustaina-

[436] *Stromabkommen EU – CH. Hintergrundnotiz*, swisselectric, UVEK, Bern, http://www.stromversorgungsrecht.ch/Internationales.html?file=tl_files/media/Themen/Internationales/20100519_swisselectric_Hintergrundnotiz_Stromabkommen.pdf (accessed: 6.11.2016).

[437] *Stromabkommen EU – CH.., op. cit.*

ble prices of energy for end customers. Liberalization will involve the ensuring of stable general conditions for the functioning of the energy market on the basis of transparent legal regulations; it will also help achieve climate and environmental goals.

Cooperation between Switzerland and the EU definitely gives benefits for both entities in the area of energy security. Mutual dependence, which results from the geographical location, is also a fact. However, the tradition of isolationism and substantial direct influence of citizens on Swiss policy means that the legal and institutional integration of the energy system with the EU is rather slow.